US006032875A

United States Patent [19]

Grimshaw-Jones

[11] **Patent Number: 6,032,875**

[45] **Date of Patent: Mar. 7, 2000**

[54] **LUBRICATED HEAVY DIESEL FUEL PUMP WITH PRECIPITATE BUILD-UP INHIBITING FEATURES**

[75] Inventor: **Stanley G. Grimshaw-Jones**, Edmonton, Canada

[73] Assignee: **Caterpillar Inc.**, Peoria, Ill.

[21] Appl. No.: **09/063,918**

[22] Filed: **Apr. 21, 1998**

[51] **Int. Cl.**[7] **B05B 15/02**; F23D 11/34

[52] **U.S. Cl.** **239/106**; 239/123; 239/92

[58] **Field of Search** 239/104, 106, 239/114–116, 123, 88–92; 92/158, 159, 208

[56] **References Cited**

U.S. PATENT DOCUMENTS

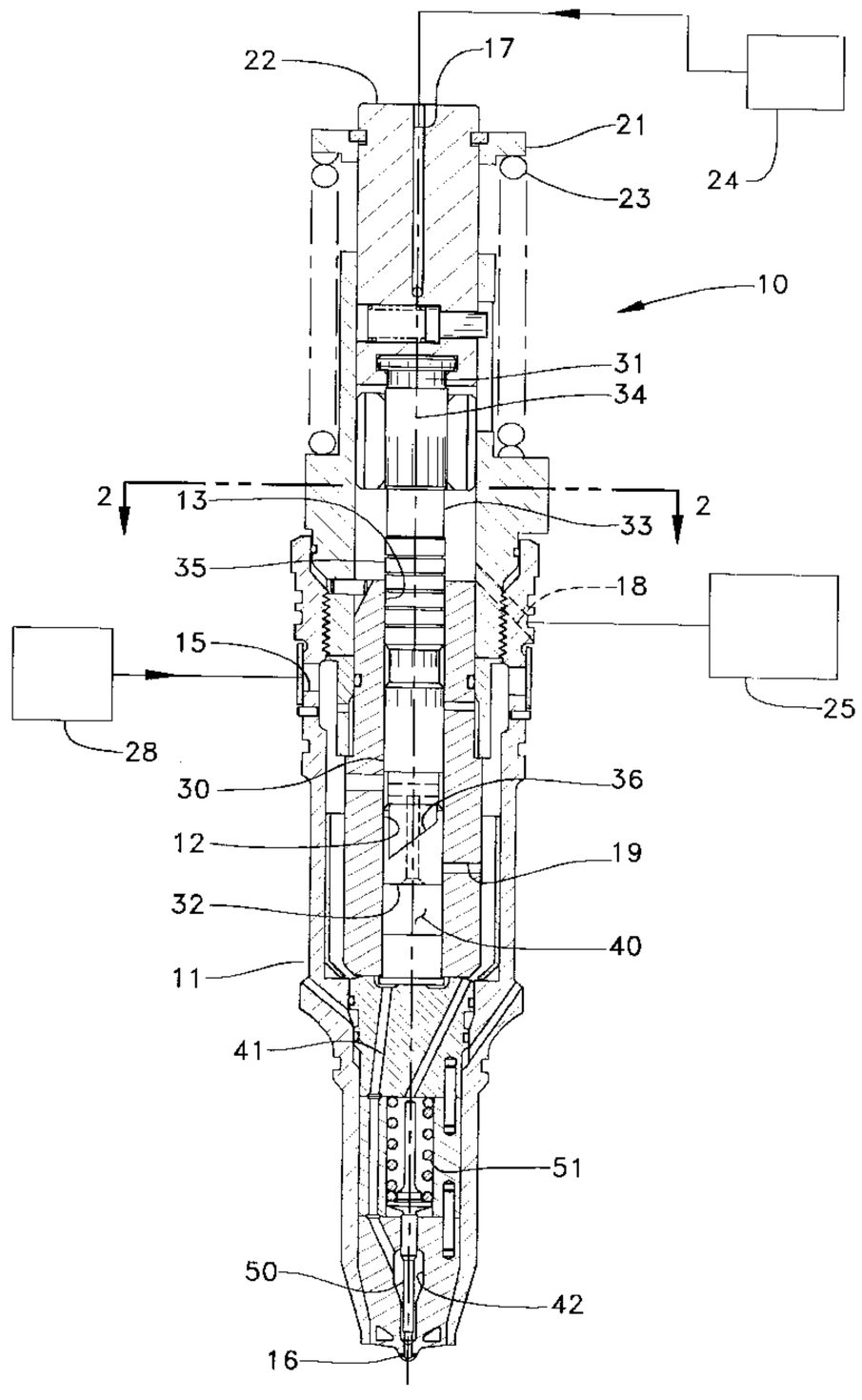
1,837,813	12/1931	Groff .	
1,850,250	3/1932	Von Salis .	
2,225,796	12/1940	Perrine .	
2,759,771	8/1956	Grigar .	
2,884,919	5/1959	Butler .	
2,932,865	4/1960	Bauer .	
3,153,987	10/1964	Thoma .	
4,304,410	12/1981	Erickson et al. .	
4,350,082	9/1982	Carrens	92/159
4,599,935	7/1986	Ellermann et al. .	
4,809,591	3/1989	Rhodes et al. .	
4,903,580	2/1990	Bruni .	
5,076,226	12/1991	Watanabe et al.	123/193 P
5,460,329	10/1995	Sturman	239/96
5,816,134	10/1998	Takenaka et al.	92/154
5,826,561	10/1998	Mack et al.	123/446

Primary Examiner—Andres Kashnikow
Assistant Examiner—Lisa Ann Douglas
Attorney, Agent, or Firm—Michael B. McNeil

[57] **ABSTRACT**

A heavy diesel fuel injection pump with precipitate build-up inhibiting features includes a pump body that defines a plunger bore. The plunger has a top end separated from a bottom end by a side surface, and is moveable in the plunger bore between a retracted position and an advanced position. A portion of the plunger bore and the bottom end of the plunger define a pump chamber containing heavy diesel fuel. The top end of the plunger is exposed to lubricating oil. The lubricating oil mixes with the heavy diesel fuel along a guide portion of the side surface of the plunger that has a tight clearance with respect to the plunger bore. At least one of the pump body and the guide portion of the plunger define a plurality of cleaning grooves located adjacent the guide portion. The cleaning grooves are sized and shaped to continuously scrape clean calcium carbonate precipitates from the plunger bore wall and plunger outer surface, and provide a volume in which the solids can accumulate until a subsequent maintenance cycle for a particular pump.

20 Claims, 2 Drawing Sheets



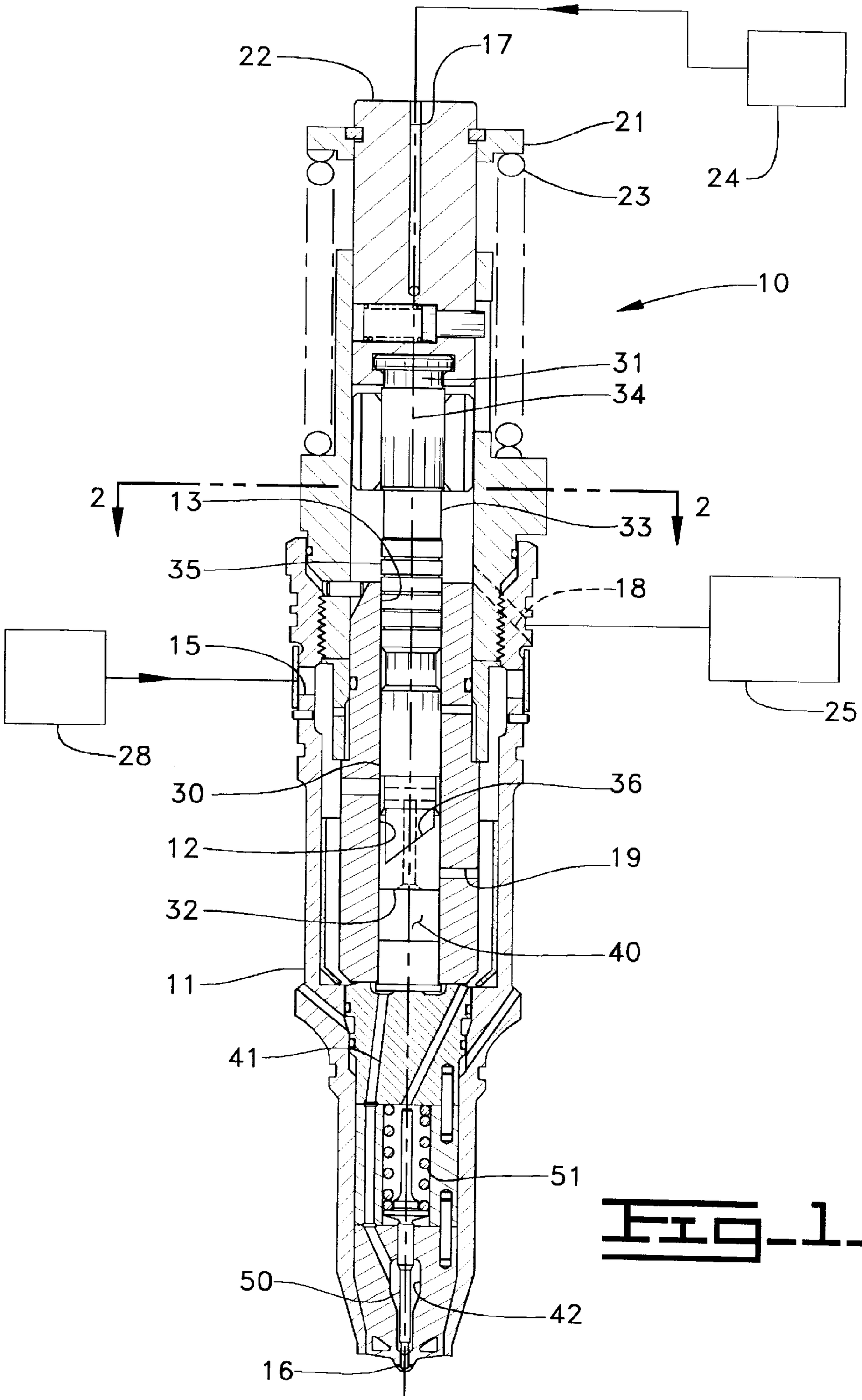

22
17
21
24
23
10
31
34
2
13
2
33
35
18
15
25
28
30
36
12
19
32
40
11
41
51
50
42
16

Fig_1_

Fig_2_

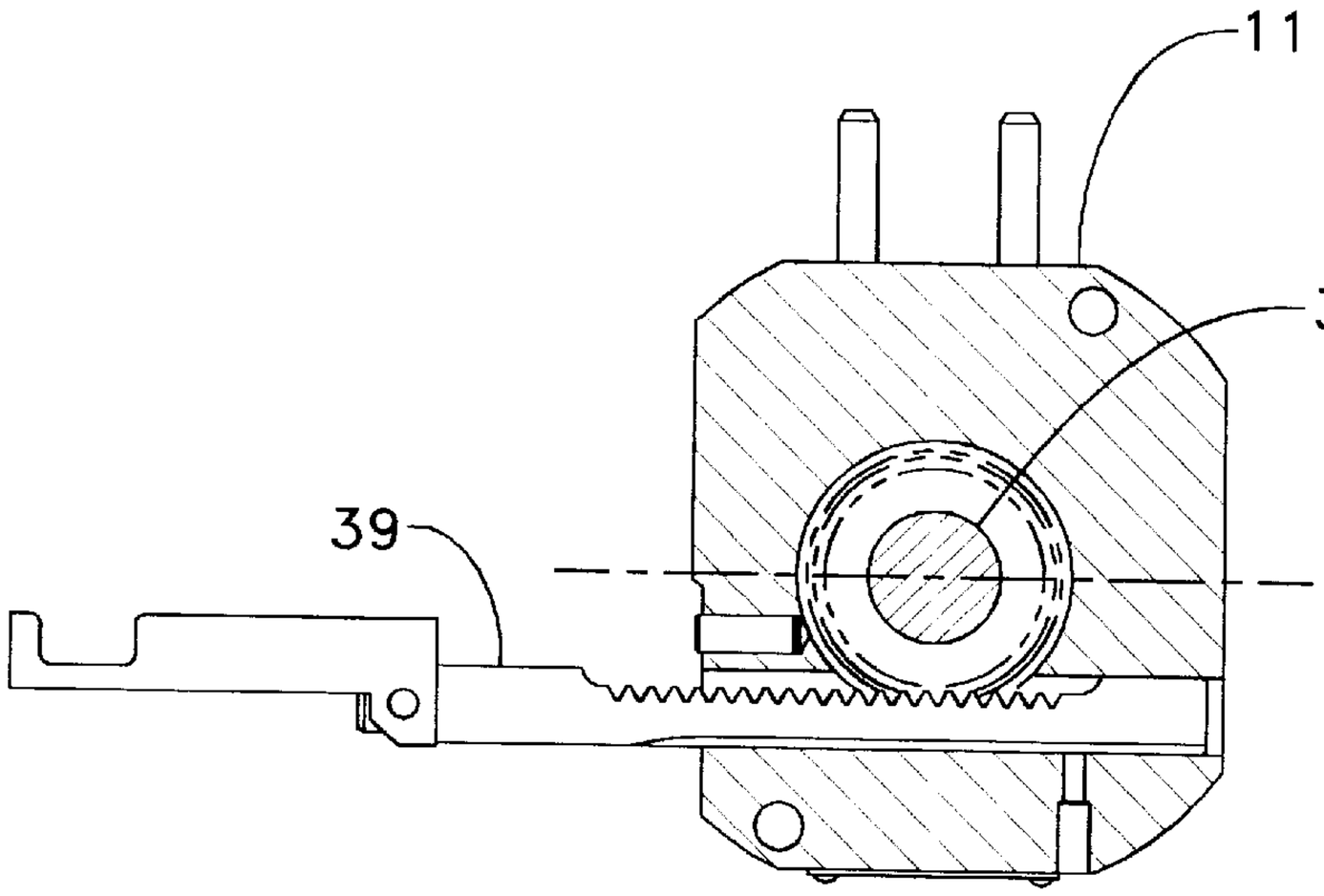
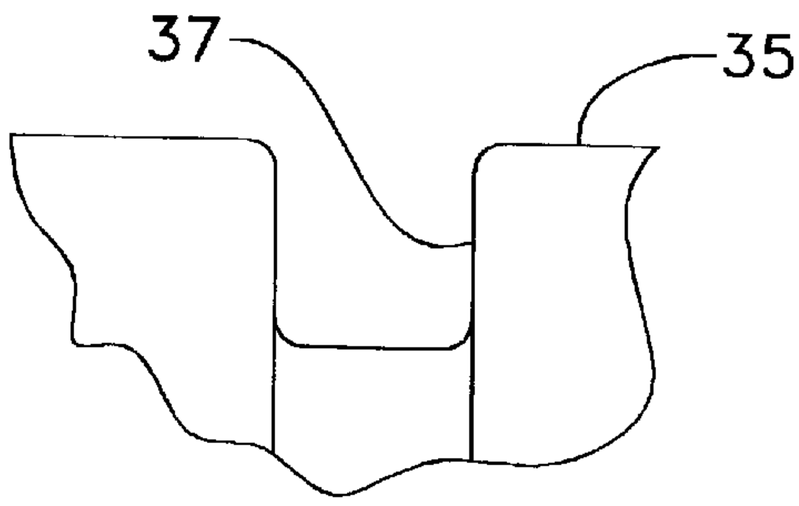


Fig_3_

Fig_4_



LUBRICATED HEAVY DIESEL FUEL PUMP WITH PRECIPITATE BUILD-UP INHIBITING FEATURES

TECHNICAL FIELD

The present invention relates generally to lubricated heavy diesel fuel pumps, and more particularly to heavy diesel fuel injection pumps having precipitate build-up inhibiting features.

BACKGROUND ART

Heavy diesel fuel refers generally to the material that is left over after crude oil has been distilled. Heavy diesel fuel typically has viscosity somewhere on the order of road tar at ambient temperatures, and must normally be heated to temperatures in excess of 400° Fahrenheit in order to make the same sufficiently flowable through a fuel injection pump. Due in part to the extremely high viscosity of heavy diesel fuel, the current state of the art in relatively large diesel engines continues to be cam actuated fuel injection pumps. In order to prevent the plunger from sticking or seizing, a lubricant, such as lubricating oil, must often be employed. In some cases, the lubricant itself can be a source of plunger sticking and seizures due to the formation of precipitates where the lubricating oil comes in contact with the heavy diesel fuel. One such precipitate includes the build-up of calcium carbonate in a plunger bore where heavy diesel fuel has migrated up the side of the plunger into contact with the lubricating oil.

Because there is often a relatively tight clearance between the reciprocating plunger and its bore, only a small amount of calcium carbonate build-up is necessary to cause the plunger to seize. Because of this problem, heavy diesel fuel injection pumps are periodically removed, disassembled, and cleaned in order to remove any calcium carbonate build-up. Depending upon what constituent chemicals are present in both the lubricating oil and the heavy diesel fuel, plunger seizures can occur in literally a matter of hours when calcium carbonate build-ups are high. More often, heavy diesel fuel injectors must typically be disassembled and cleaned about every one thousand hours of operation.

The present invention is directed to these and other problems associated with precipitate build-up in heavy diesel fuel injection pumps.

DISCLOSURE OF THE INVENTION

A lubricated heavy diesel fuel pump with precipitate build-up inhibiting features includes a pump body that defines a plunger bore. A plunger with a first end separated from a second end by a side surface is positioned in the plunger bore and moveable between a retracted position and an advanced position. A portion of the plunger bore and the first end of the plunger define a pump chamber containing heavy diesel fuel. The second end of the plunger is exposed to lubricating oil, which mixes with the heavy diesel fuel along a portion of the plunger's side surface. At least one of the pump body and plunger define at least one cleaning groove located adjacent the portion of the side surface of the plunger.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a sectioned side elevational diagrammatic view of a heavy diesel fuel injector according to the present invention.

FIG. **2** is a top sectioned diagrammatic view of the fuel injector of FIG. **1** as viewed along section lines **2**—**2**.

FIG. **3** is an enlarged partial side diagrammatic view of a plunger according to one aspect of the present invention.

FIG. **4** is an enlarged partial view of a guide portion with grooves according to present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring now to FIGS. **1**–**3**, a heavy diesel fuel injector **10** includes a pump body **11** that defines a plunger bore **12**. Pump body **11** also defines a nozzle outlet and a heavy diesel fuel inlet **15** connected to a source of heavy diesel fuel **28**. A plunger is positioned in plunger **12** and is moveable between a retracted position, as shown, and an advanced position with each pumping cycle of fuel injector **10**. Plunger **30** includes a top end **31** separated from a bottom end **32** by a side surface **33**. Plunger **30** moves along a plunger centerline **34** and has a generally cylindrical shape. The bottom end **32** of plunger **30** and a portion of plunger bore **12** define a fuel pressurization chamber **40** that is in fluid communication with a nozzle chamber **42** via a nozzle connection passage **41**.

A needle valve member **50** is positioned in pump body **11** and is moveable between an inject position in which nozzle chamber **42** is open to nozzle outlet **16**, and a closed position in which nozzle chamber **42** is blocked to nozzle outlet **16**. Needle valve member **50** is biased toward its closed position by a needle return spring **51**. As in a conventional injector that uses distillate fuel, an amount of heavy diesel fuel enters pump body **11** when plunger **30** is undergoing its upward return stroke. An amount of fuel is pumped out of nozzle outlet **16** with each downward pumping stroke of plunger **30**. The amount of fuel that leaves nozzle outlet **16** with each pumping stroke of plunger **30** is determined by the orientation of helical fuel spill slot **36** with regard to fuel spill passage **19**. This angular orientation is controlled by a fuel metering rack and pinion device **39** in a convention manner.

The top end **31** of plunger **30** is attached to a tappet **21**. Tappet **21** includes a rocker arm contact surface **22** that defines a lubricating oil inlet **17** which is connected to a source of lubricating oil **24**. In order to maintain plunger **30** appropriately lubricated, engine lubricating oil enters at oil inlet **17**, circulates around first end **31** and along side surface **33**, and eventually leaks back out of pump body **11** through lubricating oil outlet **18**. The oil then eventually returns to the oil sump **25** for recirculation in a conventional manner. Both tappet **21** and plunger **30** are retracted between injection events by a tappet return spring **23**.

Side surface **33** of plunger **30** includes a guide portion **35** that has a relatively tight clearance with respect to guide bore portion **13** of plunger bore **12**. Because of the relatively tight clearance in this area, there is a need for lubrication in order to prevent plunger **30** from becoming stuck. Although lubricating oil is at a relatively low pressure when supplied to injector **10**, some of the lubricating oil finds its way into guide bore portion **13** in order to maintain proper lubricity around guide portion **35**. Unfortunately, lubricating oil has a tendency to react with heavy diesel fuel and produce precipitates, especially calcium carbonate deposits wherever the two liquids come in contact. Because of the relatively high pressures experienced in pump chamber **40** during an injection event, over time an amount of heavy diesel fuel will migrate up the side surface **33** of plunger **30** and come in contact with downward migrating lubricating oil in the area of guide bore portion **13**.

In order to prevent the build-up of calcium carbonate and other possible precipitates that can cause plunger seizure,

guide portion **35** of the present invention includes five spaced apart cleaning grooves **37**. As plunger **30** reciprocates up and down, the edges of cleaning grooves **37** continuously scrape guide bore portion **13** free of calcium carbonate precipitate deposits. In addition to providing an edge by which these deposits can be continuously cleaned from the bore wall, the volume defined by the cleaning grooves provides a location where the deposits can accumulate without undermining the performance of heavy diesel fuel injector **10**. In order to prevent the introduction of unnecessary stress points produced by right angles on plunger **30**, grooves **37** preferably have a unshaped bottom and slightly rounded edges.

Industrial Applicability

There are several competing considerations that need to be taken into account when one is determining the size, shape and number of cleaning grooves for a particular heavy diesel fuel injection pump. In order to prevent binding and insure that plunger **30** continues to move along centerline **34**, it is important that guide portion **35** have a relatively large surface contact area. Thus, the accumulated widths of all of the cleaning grooves **37** subtract some measurable amount from this surface area. On the other hand, the cleaning grooves must have sufficient widths to provide a scrape surface edge instead of becoming plugged quickly with calcium carbonate build-up. Experimental efforts have shown that cleaning groove widths greater than about 0.1 millimeter will not become plugged, but it is generally desired that the widths be less than 0.5 millimeters in order to preserve a maximum guide surface contact area on guide portion **35**.

Another consideration is the depth of the cleaning grooves **37**. Here again, conflicting considerations are at work. If the cleaning grooves are too shallow, there is insufficient volume available for the accumulation of precipitate solids, and therefore, injector **10** would still have to be disassembled and cleaned almost as often as if there were no grooves at all, as in the prior art. On the other hand, if the depth of cleaning grooves **37** is too deep, the strength of plunger **30** can be undermined and high stress points can be created, which could eventually lead to plunger breakage. It has been found that creating cleaning grooves with a depth of greater than about 0.1 millimeter but less than 0.5 millimeters provides an adequate volume for the accumulation of precipitate solids without seriously undermining the strength of plunger **30**.

Another consideration is how many cleaning grooves should be provided. While the preferred embodiment shows annular cleaning grooves that lay in planes perpendicular to centerline **34**, some other arrangement could be provided. One such possibility could be a single helically shaped cleaning groove that encircles plunger **30** about four or five times along its length. Another desirable possibility might be a double, oppositely oriented, helix configuration. Such a configuration would allow scraping to take place both when the plunger is reciprocating and when it is rotating due to the metering function. In any event, it is preferable that the cleaning grooves be equally spaced apart and spread out over the length of guide portion **35** in order to minimize the impact on the guide surface area. It has been found that five equally spaced cleaning grooves has worked better than three equally spaced cleaning grooves. However, it is possible that six or more spaced apart cleaning grooves could perform satisfactorily.

Another consideration is the prevention of the entry of heavy diesel fuel into the lubricating oil flow circuit in order to prevent the creation and deposit of calcium carbonate precipitates at other locations within an internal combustion engine. It has been found that the use of five spaced apart cleaning grooves as shown in FIG. **3** provides a continuous cleaning function of the present invention, and does so without significantly raising the amount of heavy diesel fuel that makes its way into the lubricating oil circuitry of the engine. Even with the cleaning grooves of the present invention, fuel injector **10** will periodically need to be disassembled and the accumulated solids in the cleaning grooves **37** removed in any suitable manner known in the art. However, it is believed that by including cleaning grooves according to the present invention, the time between these maintenance cycles for a given injector can be greatly increased over that of prior art heavy diesel fuel injection pumps.

The above description is intended for illustrative purposes only, and is not intended to limit the scope of the present invention in any way. For instance, those skilled in the art will appreciate that the cleaning grooves of the present invention could also be made on the inner guide bore portion of the pump body instead of on the outer surface of the plunger as shown in the preferred embodiment. In addition, in order to obtain the maximum benefit of the cleaning grooves according to the present invention, it is desirable that the grooves sweep out the complete length of the guide bore portion **13** with each reciprocation of plunger **30** during normal loaded operating conditions of the engine in which injector **10** is mounted. Thus, various modifications could be made to the disclosed embodiment without departing from the intended spirit and scope of the present invention, which is defined in terms of the claims as set forth below.

We claim:

1. A lubricated heavy diesel fuel pump with precipitate build-up inhibiting features, comprising:

a pump body defining a plunger bore;

a plunger with a first end separated from a second end by a side surface, and being positioned in said plunger bore and moveable between a retracted position and an advanced position;

a portion of said plunger bore and said first end of said plunger defining a pump chamber containing heavy diesel fuel;

said second end of said plunger being exposed to lubricating oil and;

at least one of said pump body and plunger defining at least one cleaning groove located adjacent said portion of said side surface.

2. The pump of claim **1** wherein a portion of said side surface is a guide portion with a tight clearance with respect to said plunger bore; and

said guide portion defining a plurality of cleaning grooves.

3. The pump of claim **1** wherein said at least one cleaning groove is annular and lies in a plane perpendicular to a centerline of said plunger.

4. The pump of claim **1** wherein said portion has a length; and

said at least one cleaning groove sweeps over said length when said plunger moves between said retracted position and said advanced position.

5. The pump of claim **1** wherein said at least one cleaning groove has a width greater than 0.1 mm but less than 0.5 mm.

6. The pump of claim **1** wherein said at least one cleaning groove has a depth greater than 0.1 mm but less than 0.5 mm.

7. The pump of claim 1 wherein said portion defines at least five spaced apart annular cleaning grooves that lie in planes perpendicular to a centerline of said plunger and having widths greater than 0.1 mm.

8. The pump of claim 1 wherein said pump body defines a nozzle outlet in fluid communication with said pump chamber; and

a needle valve member positioned in said pump body and being moveable between an inject position in which said nozzle outlet is open, and a closed position in which said nozzle outlet is blocked.

9. A heavy diesel fuel injection pump with precipitate build-up inhibiting features, comprising:

a pump body defining a plunger bore;

a plunger with a first end separated from a second end by a side surface, and being positioned in said plunger bore and moveable between a retracted position and an advanced position;

a portion of said plunger bore and said first end of said plunger defining a pump chamber containing heavy diesel fuel;

said second end of said plunger being exposed to lubricating oil; a guide portion of said side surface having a tight clearance with respect to said plunger bore; and

at least one of said pump body and said guide portion of said plunger defining a plurality of cleaning grooves located adjacent said guide portion.

10. The heavy diesel fuel injection pump of claim 9 wherein said plurality of cleaning grooves are annular and lie in planes perpendicular to a centerline of said plunger.

11. The heavy diesel fuel injection pump of claim 9 wherein said guide portion has a length; and

said plurality of cleaning grooves sweep over said length when said plunger moves between said retracted position and said advanced position.

12. The heavy diesel fuel injection pump of claim 9 wherein said plurality of cleaning grooves have widths greater than 0.1 mm but less than 0.5 mm.

13. The heavy diesel fuel injection pump of claim 9 wherein said plurality of cleaning grooves have depths greater than 0.1 mm but less than 0.5 mm.

14. The heavy diesel fuel injection pump of claim 9 wherein said guide portion defines at least five spaced apart annular cleaning grooves that lie in planes perpendicular to a centerline of said plunger and having widths greater than 0.1 mm.

15. The heavy diesel fuel injection pump of claim 9 wherein said pump body defines a nozzle outlet in fluid communication with said pump chamber; and

a needle valve member positioned in said pump body and being moveable between an inject position in which said nozzle outlet is open, and a closed position in which said nozzle outlet is blocked.

16. A heavy diesel fuel injection pump with precipitate build-up inhibiting features, comprising:

a pump body defining a plunger bore in fluid communication with a nozzle outlet;

a plunger with a first end separated from a second end by a side surface, and being positioned in said plunger bore and moveable between a retracted position and an advanced position;

a portion of said plunger bore and said first end of said plunger defining a pump chamber containing heavy diesel fuel;

said second end of said plunger being exposed to lubricating oil;

at least one of said pump body and plunger defining at least one cleaning groove located adjacent said portion of said side surface; and

a needle valve member positioned in said pump body and being moveable between an inject position in which said nozzle outlet is open, and a closed position in which said nozzle outlet is blocked.

17. The heavy diesel fuel injection pump of claim 16 wherein a portion of said side surface defines a plurality of cleaning grooves that are annular and lie in planes perpendicular to a centerline of said plunger.

18. The heavy diesel fuel injection pump of claim 17 wherein said portion has a length; and

said plurality of cleaning grooves sweep over said length when said plunger moves between said retracted position and said advanced position.

19. The heavy diesel fuel injection pump of claim 18 wherein said plurality of cleaning grooves is at least five cleaning grooves having widths greater than 0.1 mm.

20. The heavy diesel fuel injection pump of claim 19 wherein said plurality of cleaning grooves have depths greater than 0.1 mm.

* * * * *